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# ACOUSTIC FILL FACTORS FOR A 120-INCH DIAMETER FAIRING

submitted by

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## SUMMARY

Data from the acoustic test of a 120-inch diameter payload fairing were collected and an analysis of acoustic fill factors was performed. Correction factors for obtaining a weighted spatial average of the interior SPL were derived based on this database and a normalized 200-inch diameter fairing database. The weighted fill factors were determined and compared with statistical energy analysis (VAPEPS code) derived fill factors. The comparison is found to be reasonable.

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## 1. INTRODUCTION

The database used in the fill factor study of Ref. (1) consists of the acoustic data from tests and analyses of 200-inch and 120-inch diameter fairings. Microphone data from the 200-inch diameter fairing is rather complete and well defines the radial distribution of sound pressure level (SPL) of an empty fairing. However, for the 120-inch diameter fairing, the original microphone data were not accessible while the only data available were the deduced fill factors. The fill factors were most likely based on the simple average of a few internal microphones in the definition of the empty fairing environment. In this report, the original acoustic data for the 120-inch empty fairing are collected and analyzed. A correction factor schedule was determined to correct the simple averaged fill factor to weighted fill factors. The weighted fill factors are compared with the VAPEPS derived fill factors and found to be in reasonable agreement.

## 2. DATABASE

Internal SPL's of the 120-inch diameter empty fairing were measured with five (5) microphones. The locations of microphones M9 through M13 are shown in Figure 1. Microphones M9, M10, and M11 were located 18 inches radially from the center while M12 and M13 were 30 inches radially from the center. Microphones M9, M10, and M11 were at different longitudinal stations while M12 and M13 were at the same longitudinal station. Figures 2 and 3 show the measured SPL in the fairing with and without acoustic blanket linings, respectively. Although there are five microphones, they really represent the SPL at only 2 radial stations ( $R=18$  and 30 inches). The average of M9, M10, and M11 at  $R=18$  inches and the average of M12 and M13 at  $R=30$  inches are shown in Figures 4 and 5. They are not sufficient to represent the radial distribution over the cross section of an empty fairing. To mend this deficiency, the database of the 200-inch diameter fairing was used to derive the radial distribution of stations from  $R=30$  inches to 60 inches. This is the same database used in deriving the fill factor of the 200-inch payload fairing in ref. (1). Figure 6 shows the radial distribution in the 200-inch diameter fairing. It has been normalized to the SPL at the center. To convert this distribution to the 120-inch diameter

fairing, the frequency must be multiplied by a factor of  $200/120 = 1.667$ . This amounts to a frequency shift up by two  $1/3$ -octaves. The radial distance must be multiplied by a factor of  $120/200 = 0.6$ . Figure 7 shows the frequency and radial distance corrected radial distribution and it has been normalized to the SPL at  $R=27$  inches.

### 3. CORRECTIONS FOR AREA-WEIGHTED AVERAGE

To perform area-weighted averaging, the cross section of the 120-inch diameter fairing is divided into 6 annular zones with parameters shown in Table 1. Combining the measured SPL in Figure 4 with the radial distribution in Figure 7 and assuming the SPL in Zone 1 and Zone 2 are the same, the composite radial distribution of the 120-inch diameter fairing, with blanket, was obtained and is shown in Figure 8. Following the same procedures, the combination of Figure 5 and Figure 7 gives a composite radial distribution of the 120-inch diameter fairing without blanket as shown in Figure 9. The fill factors of the 120-inch diameter fairing shown in Ref. (1), are relative to the simple averages of the microphones in Zone 2 and Zone 3 of an empty fairing. Simple averages are performed over zones 1 through 3, and area-weighted averages are performed over zones 1 through 6. The differences (in dB) of weighted and simple averages are shown in Figures 10 and 11 for the 120-inch diameter fairing, with and without blanket, respectively. This is the correction factor schedule used to derive weighted fill factors from simple fill factors.

### 4. FILL FACTORS

The weighted fill factors were obtained by subtracting the correction factors in Figures 10 and 11 from the simple fill factors in Ref. (1). Figure 12 shows the resulting weighted fill factor of configuration A obtained by subtracting Figure 10 from Figure 2.8 of Ref. (1). The fill factors are still very significant below 400 Hz. The difference between 26-inch (32%) and 8-inch (75%) space is not very large. This leads one to believe there is strong coupling between these two spaces in this configuration. These spaces should not be

viewed as being separate spaces as implied by the percentage fill which is defined as if they are independent annular spaces. Figure 13 shows the resulting weighted fill factor of configuration D obtained by subtracting Figure 11 from Figure 2.15 of Ref. (1). The fill factor is very small because the microphone is near the transition region of the payload configuration in this case. Figure 14 shows the resulting weighted fill factor of configuration E obtained by subtracting Figure 11 from Figure 2.16 of Ref. (1).

A comparison of fill factors derived from the empirical database and statistical energy analyses (VAPEPS code) were made and are shown in Figure 15. Configuration A was deduced to be representative of a 75% fill condition and configuration E of a 81% fill condition. The VAPEPS derived fill factors consists of 70% and 80% fill conditions. The fill factors from the database are higher than the VAPEPS results at 50 Hz. The database elements show a dip in the 63 to 80 Hz region, and rise up and peak at 125 Hz. In general, the VAPEPS derived fill factors envelopes the database except at 50 Hz. This is consistent with the 200-inch diameter fairing results contained in Figure 4.15 of Ref. (1), which is reproduced here as Figure 16.

## REFERENCES

- (1) Y. A. Lee, W. Henricks, and J. P. Woolley, "Payload Fairing Fill Factor Prediction Methodology", NASA CR-189280, June 1992.

TABLE 1    RADIAL ZONES

<u>Zone</u>	<u>Radial Station (inch)</u>
1	0 to 10-
2	10 to 20-
3	20 to 30-
4	30 to 40-
5	40 to 50-
6	50 to 60-



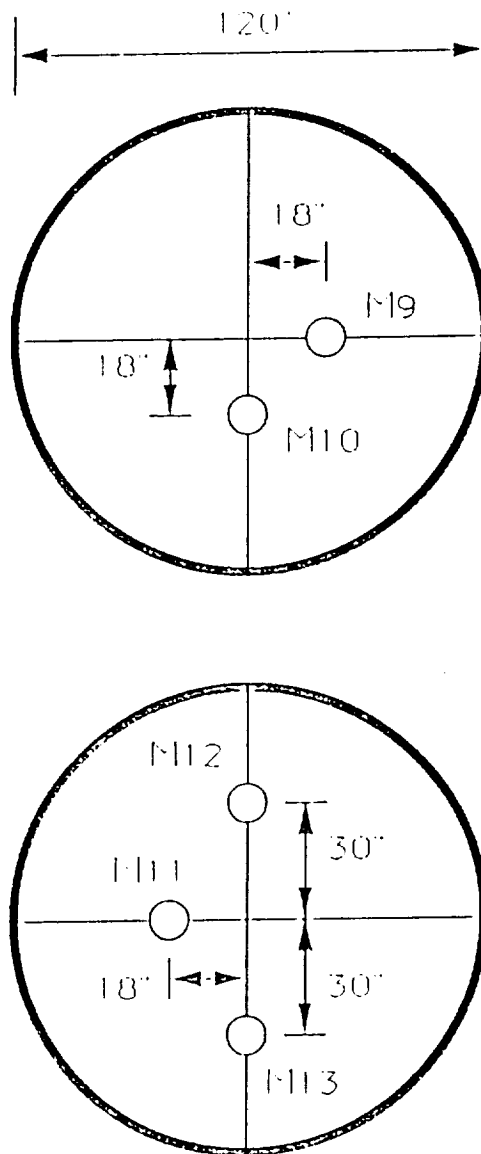


Figure 1 Location of Internal Microphones

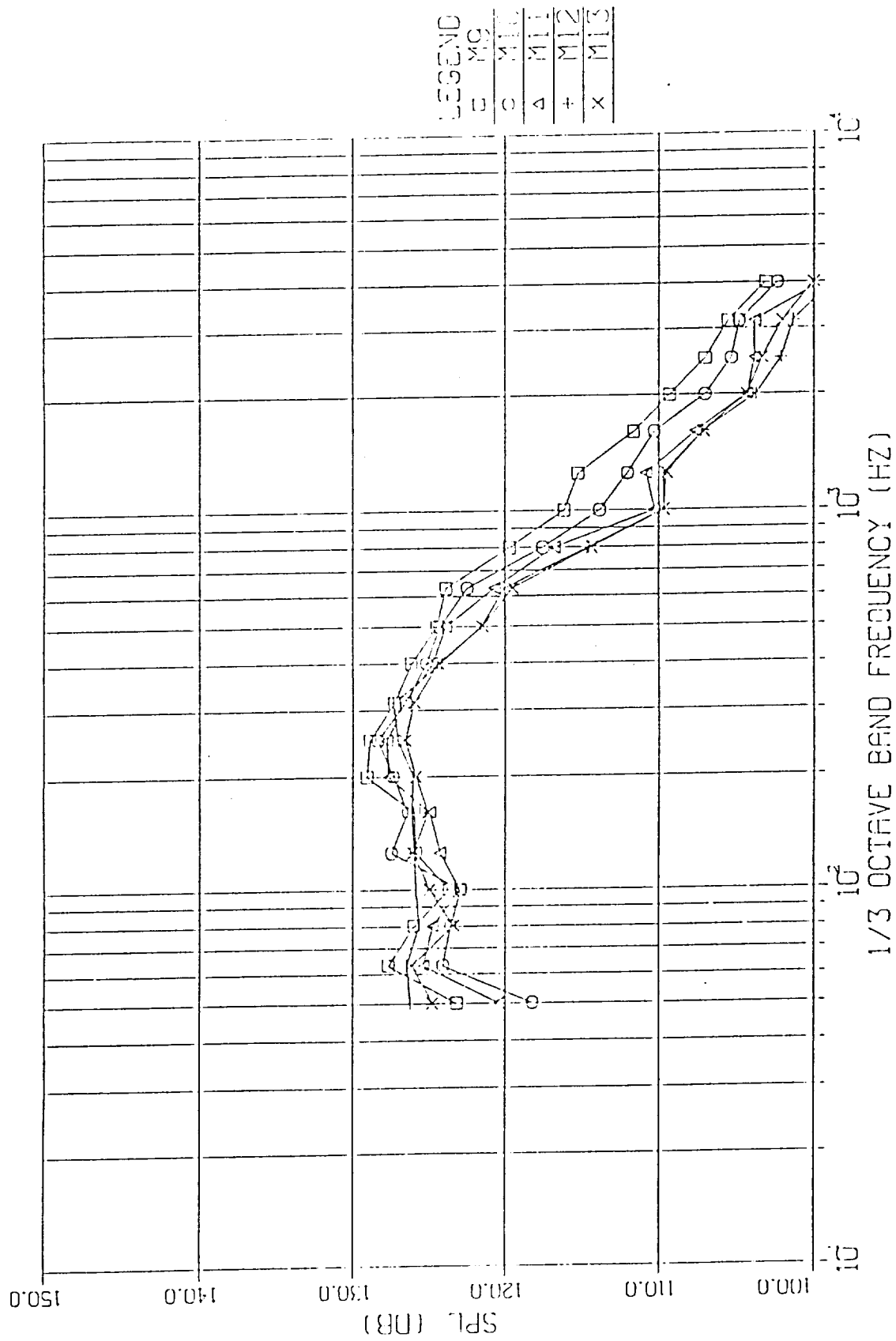


Figure 2 Internal SPL Measured in 120-inch Diameter Empty Fairing with Blanket

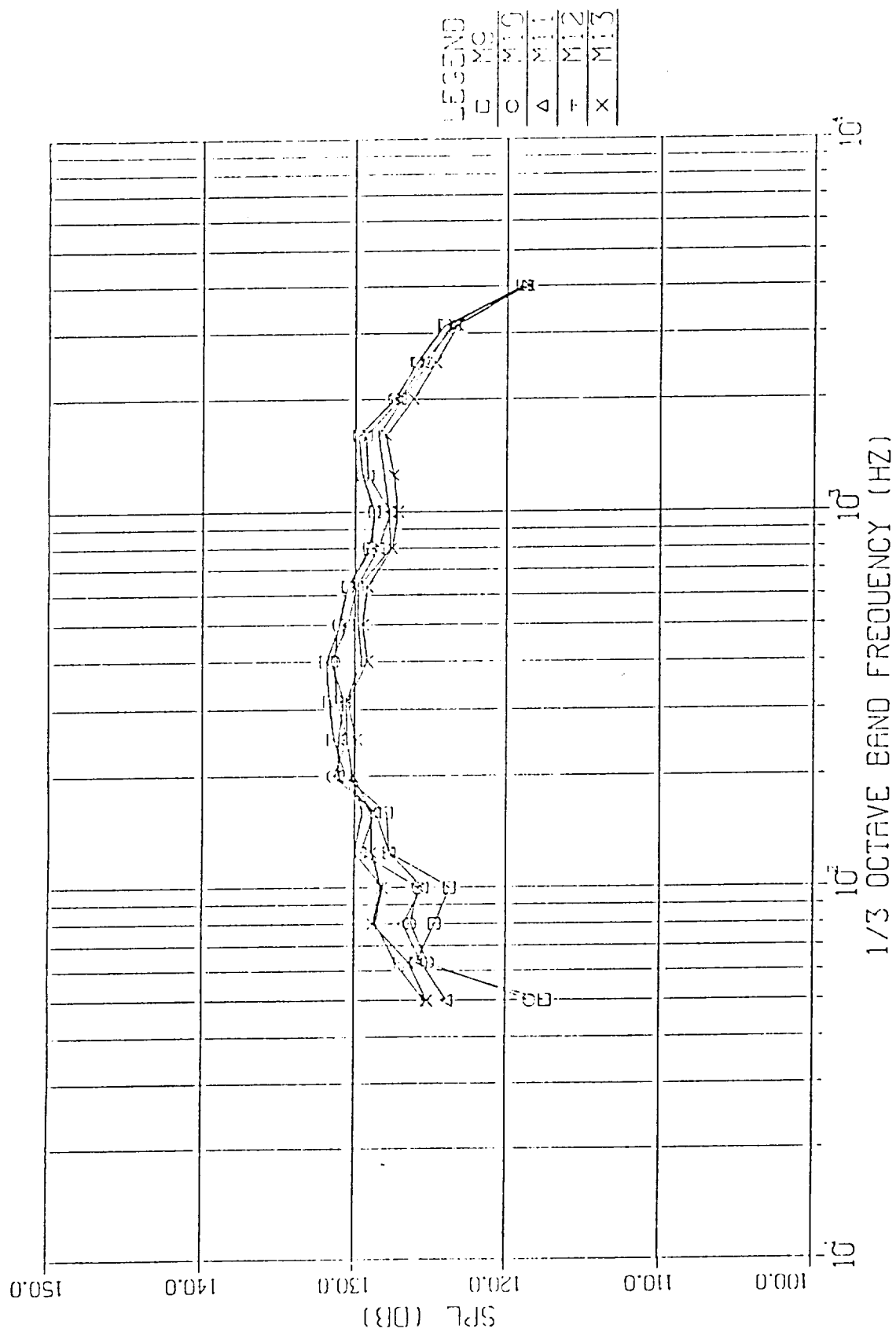


Figure 3 Internal SPL Measured in 120-inch Diameter Empty Fairing without Blanket

# AVERAGE OF MEASURED DATA 120-INCH DIAMETER FAIRING, WITH BLANKET

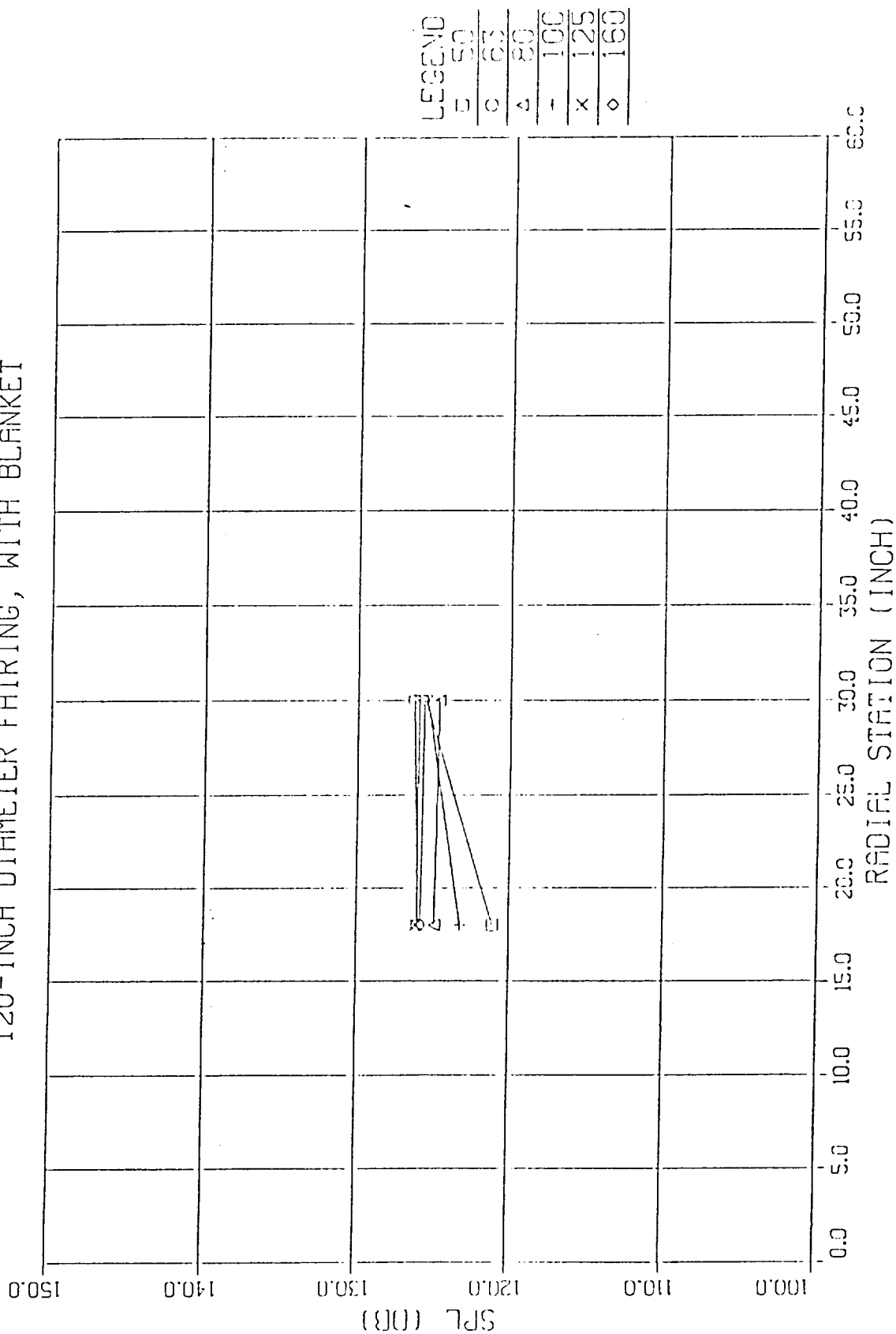


Figure 4 SPL Radial Distribution in 120-inch Diameter Empty Fairing with Blanket

# AVERAGE OF MEASURED DATA 120-INCH DIAMETER FAIRING, NO BLANKET

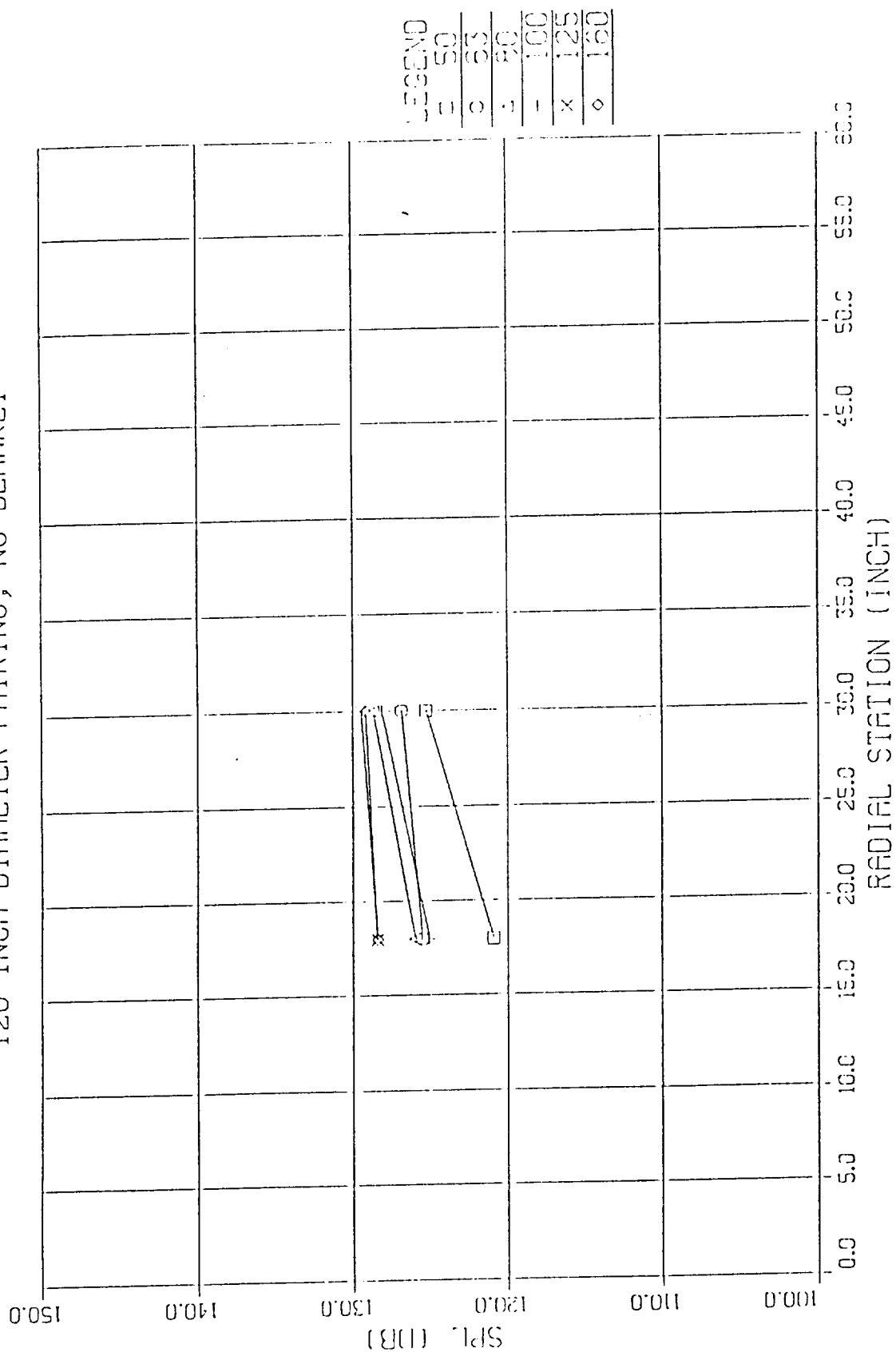


Figure 5 SPL Radial Distribution in 120-inch Diameter Empty Fairing without Blanket

RELATIVE TO SPL AT CENTER  
EMPTY FAIRING OF 200 INCH DIAMETER

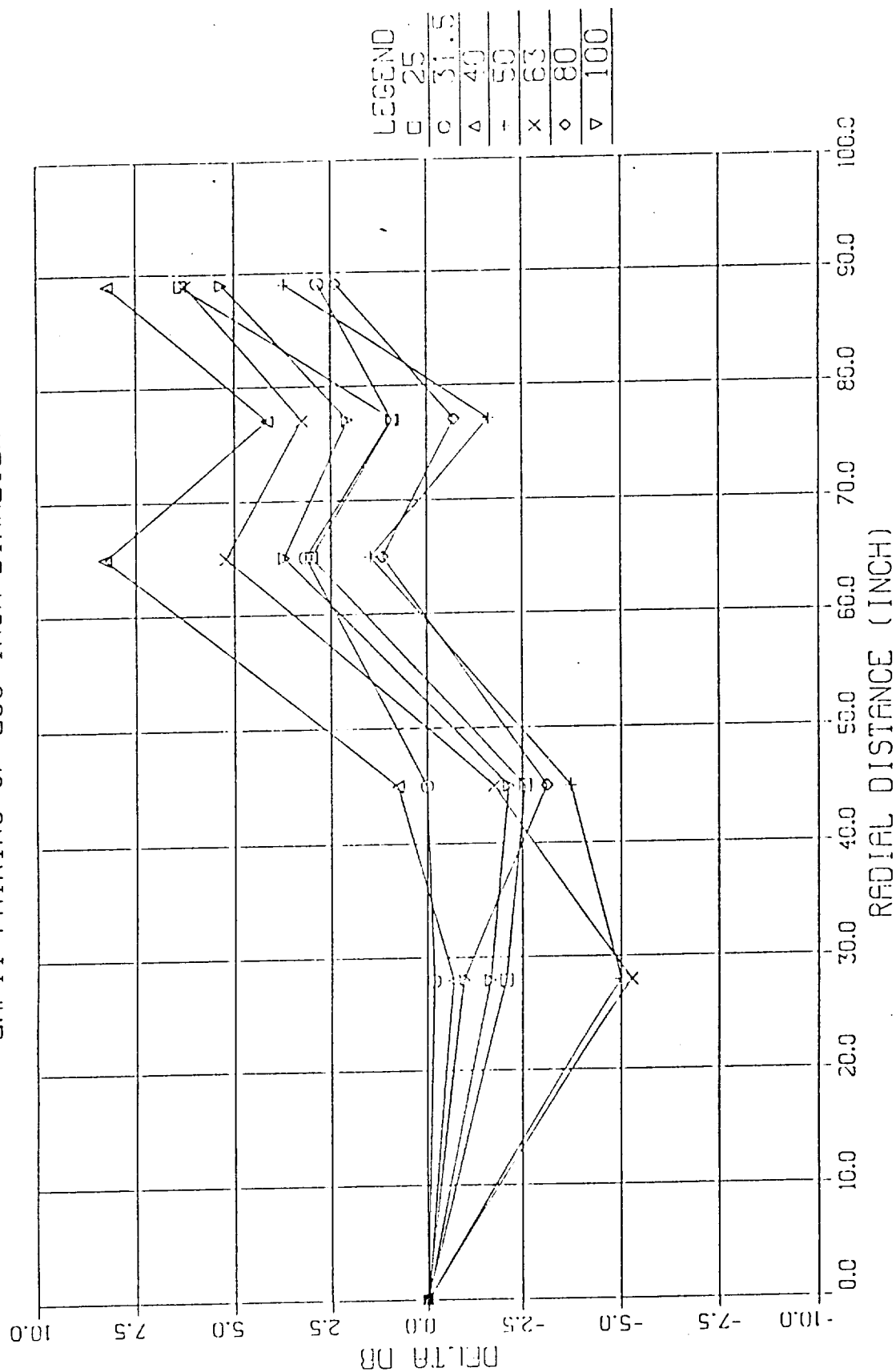


Figure 6 Normalized SPL Radial Distribution in 200-inch Diameter Empty Fairing

RELATIVE TO SPL AT R-27.  
FROM DATABASE OF EMPTY 200-INCH DIAMETER FAIRING

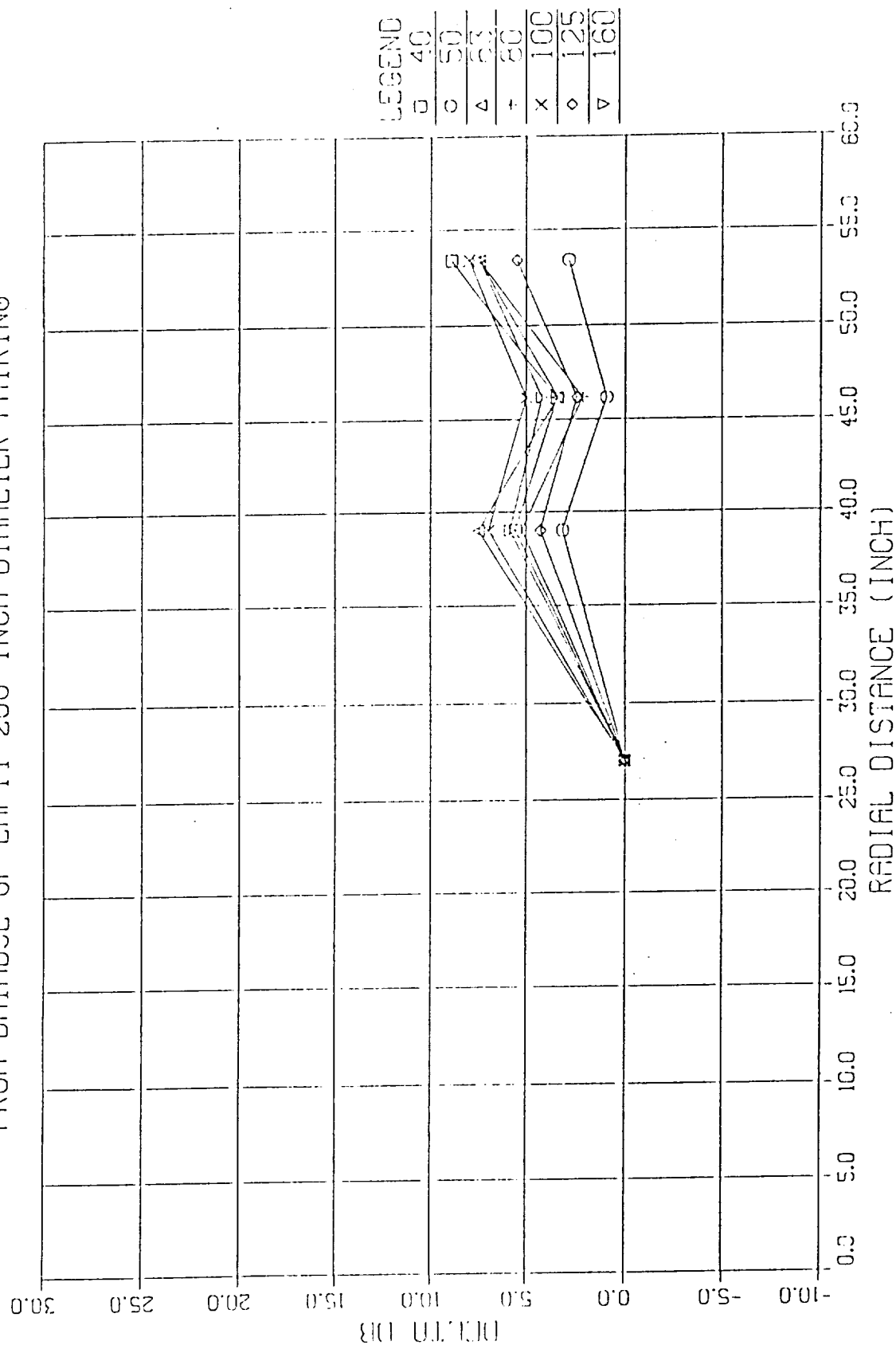


Figure 7 Corrected SPL Radial Distribution

# 120-INCH DIAMETER FAIRING, WITH BLANKET

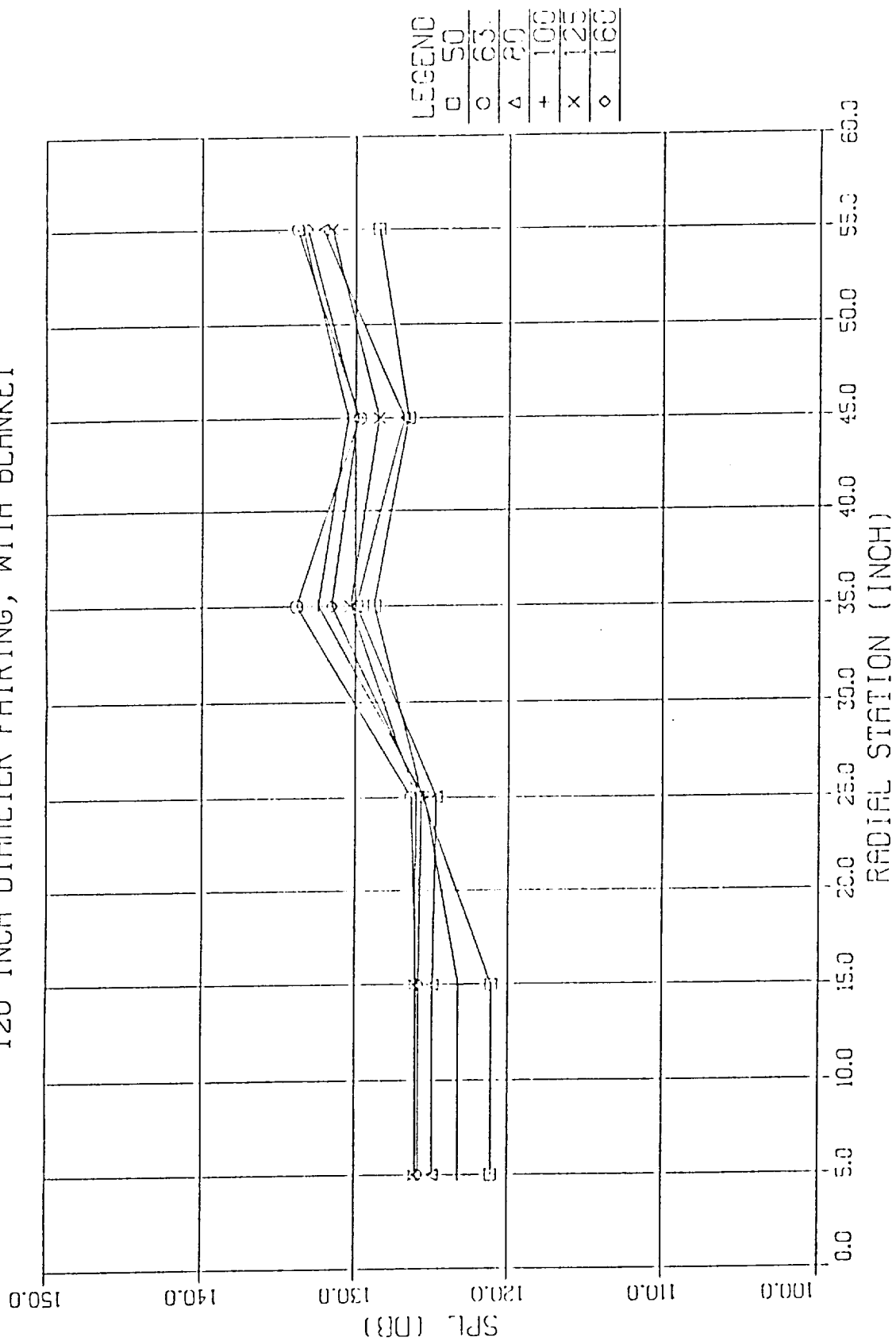


Figure 8 Composite SPL Radial Distribution of 120-inch Diameter Empty Fairing with Blanket



# 120-INCH DIAMETER FAIRING, NO BLANKET

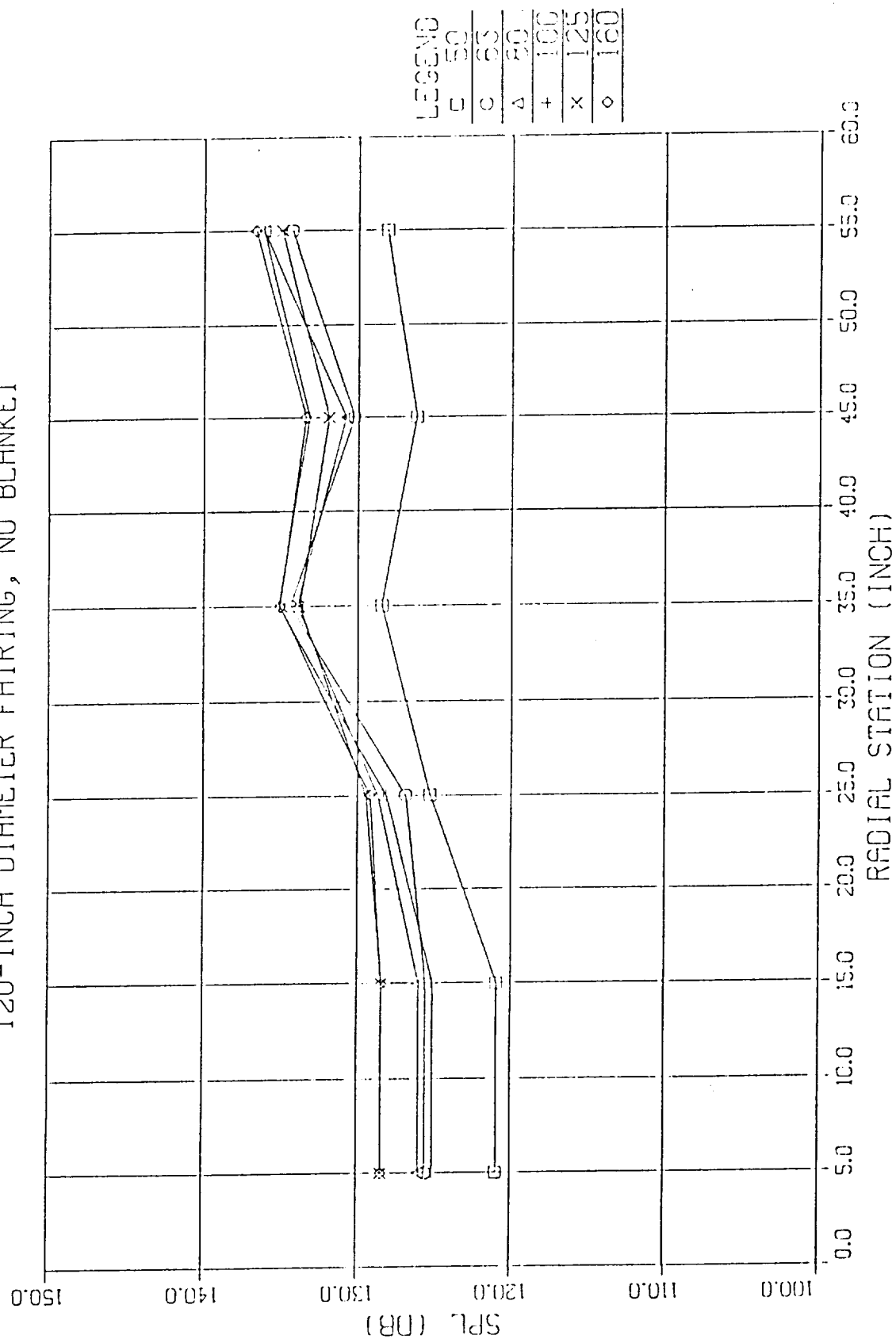


Figure 9 Composite SPL Radial Distribution of 120-inch Diameter Empty Fairing without Blanket

120-INCH DIAMETER EMPTY FAIRING, WITH BLANKET  
WEIGHTED AVG OF ZONES 1-6 MINUS SIMPLE AVG OF ZONES 1-3

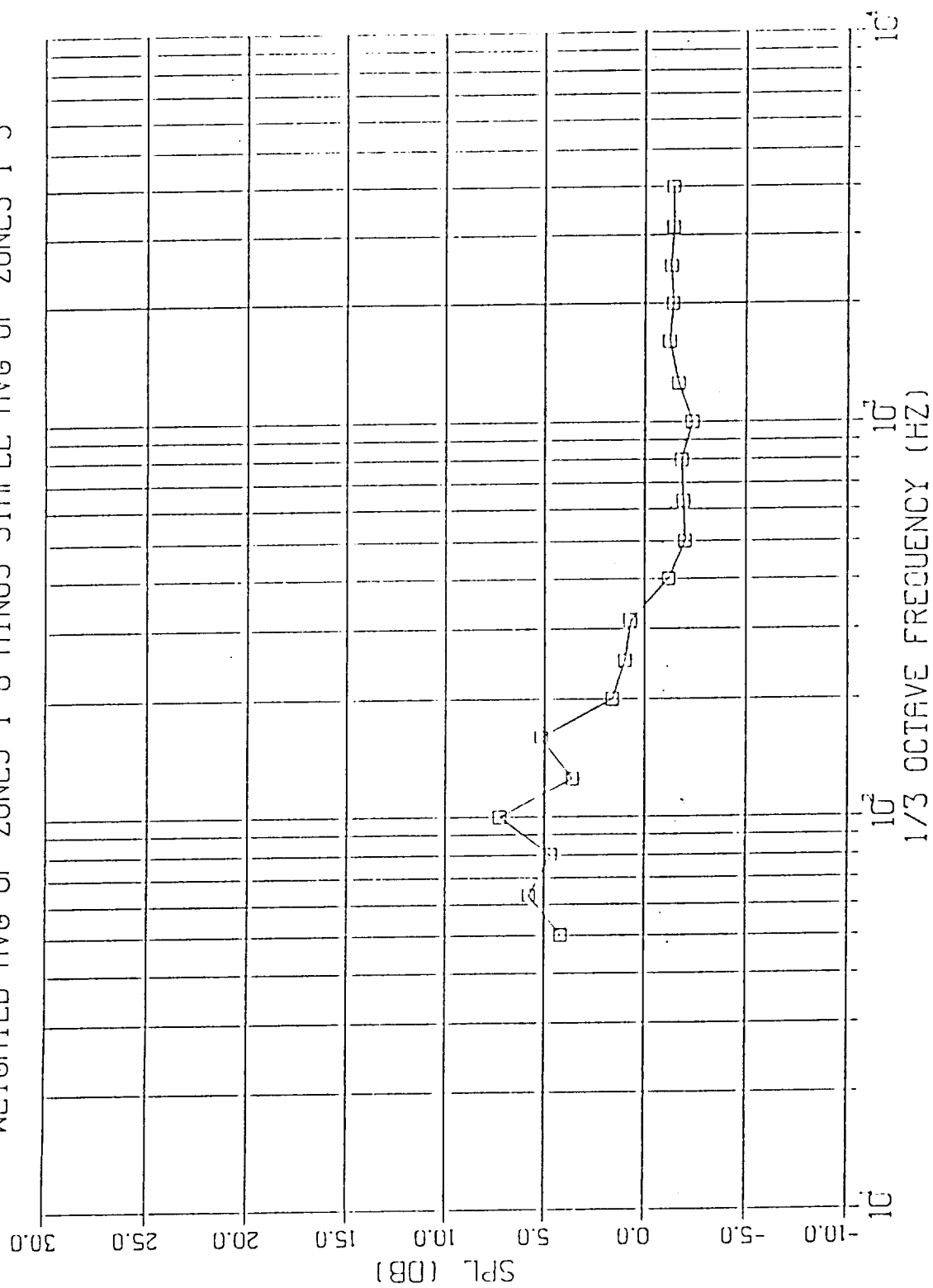


Figure 10 Fill Factor Correction for 120-inch Diameter Empty Fairing with Blanket

120-INCH DIAMETER EMPTY FAIRING, NO BLANKET  
WEIGHTED AVG OF ZONES 1-6 MINUS SIMPLE AVG OF ZONES 1-3

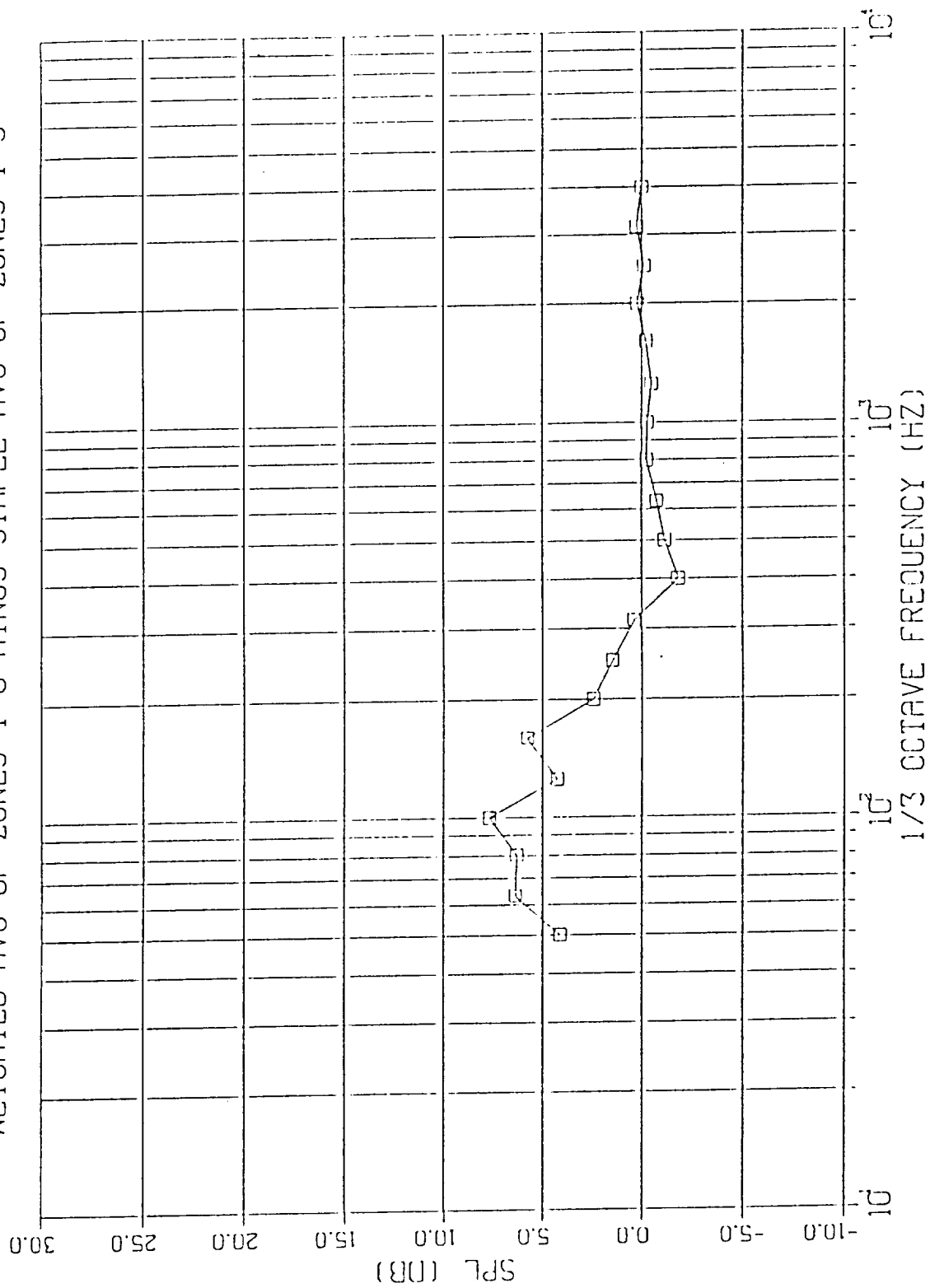


Figure 11 Fill Factor Correction for 120-inch Diameter Empty Fairing without Blanket

120-INCH DIAMETER FAIRING WITH BLANKET  
 26-IN: 26-INCH SPACE (32%) 8-IN: 8-INCH SPACE (75%)

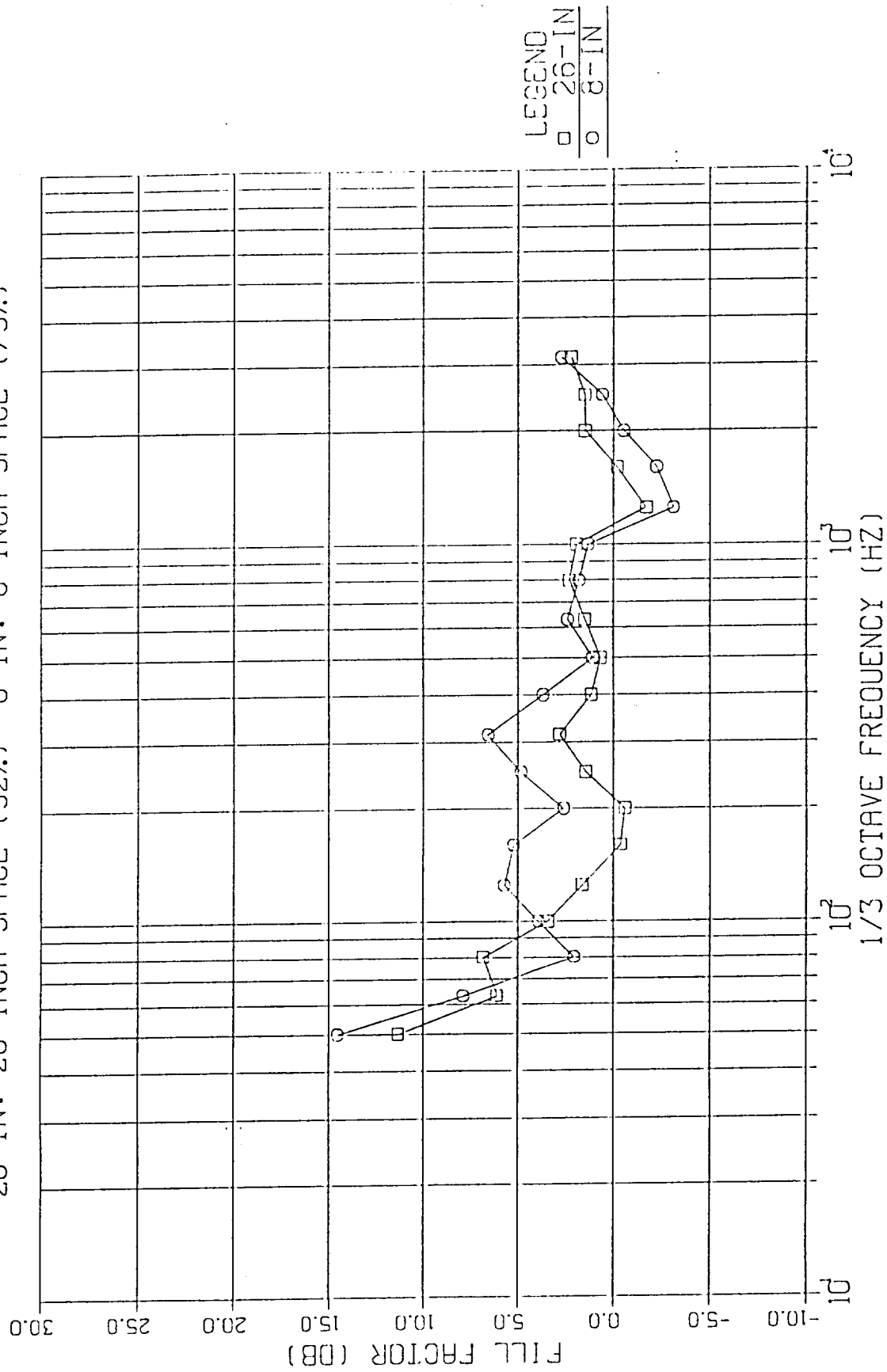


Figure 12 Weighted Fill Factor of Configuration A in 120-inch Diameter Fairing

120-INCH DIAMETER FAIRING WITHOUT BLANKET  
8-IN: 8-INCH SPACE (75%)

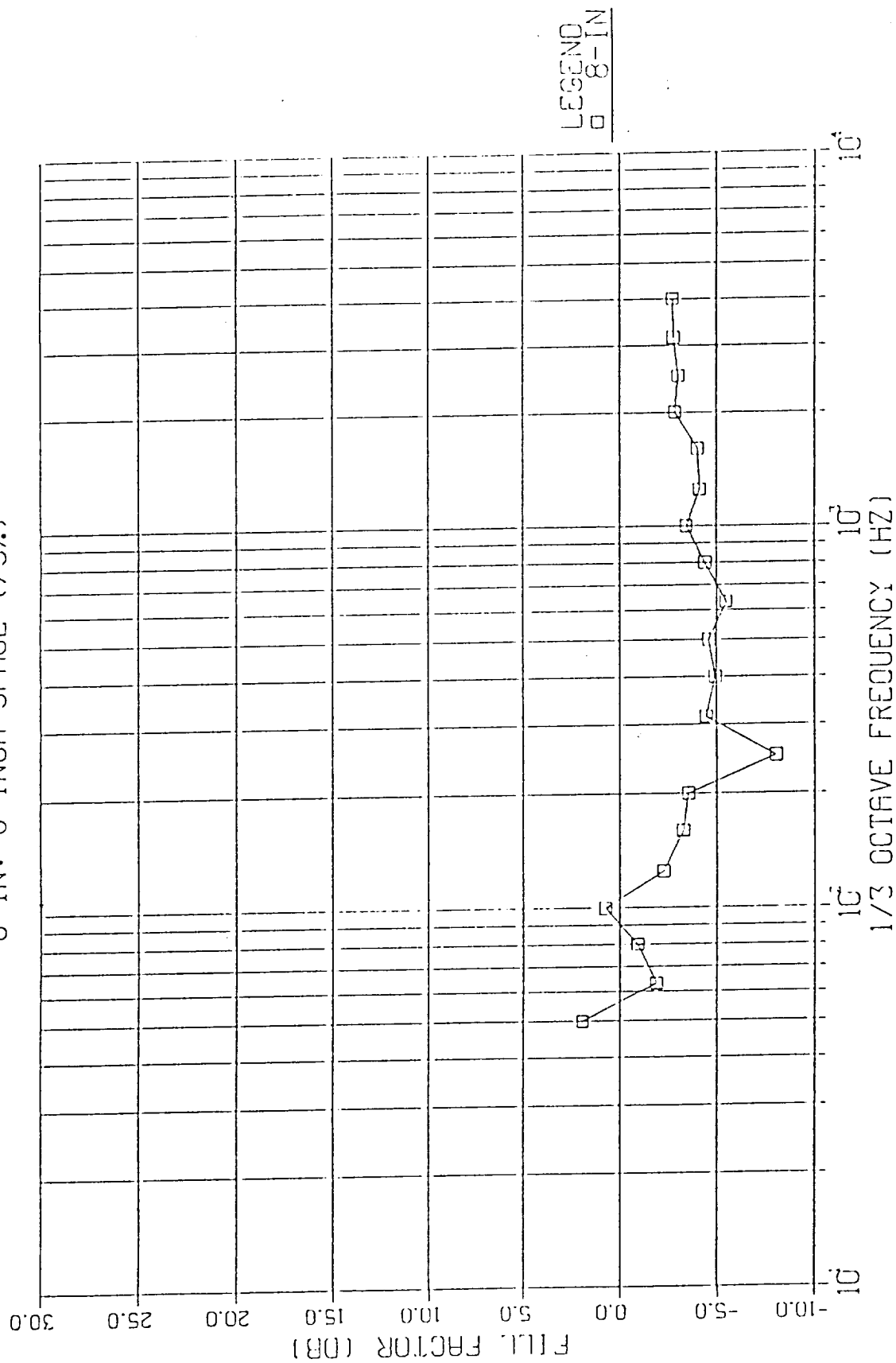


Figure 13 Weighted Fill Factor of Configuration D in 120-inch Diameter Fairing

120-INCH DIAMETER FAIRING WITHOUT BLANKET  
 PLE4: 6-INCH SPACE (81%) PLE5: 6-INCH SPACE (81%)

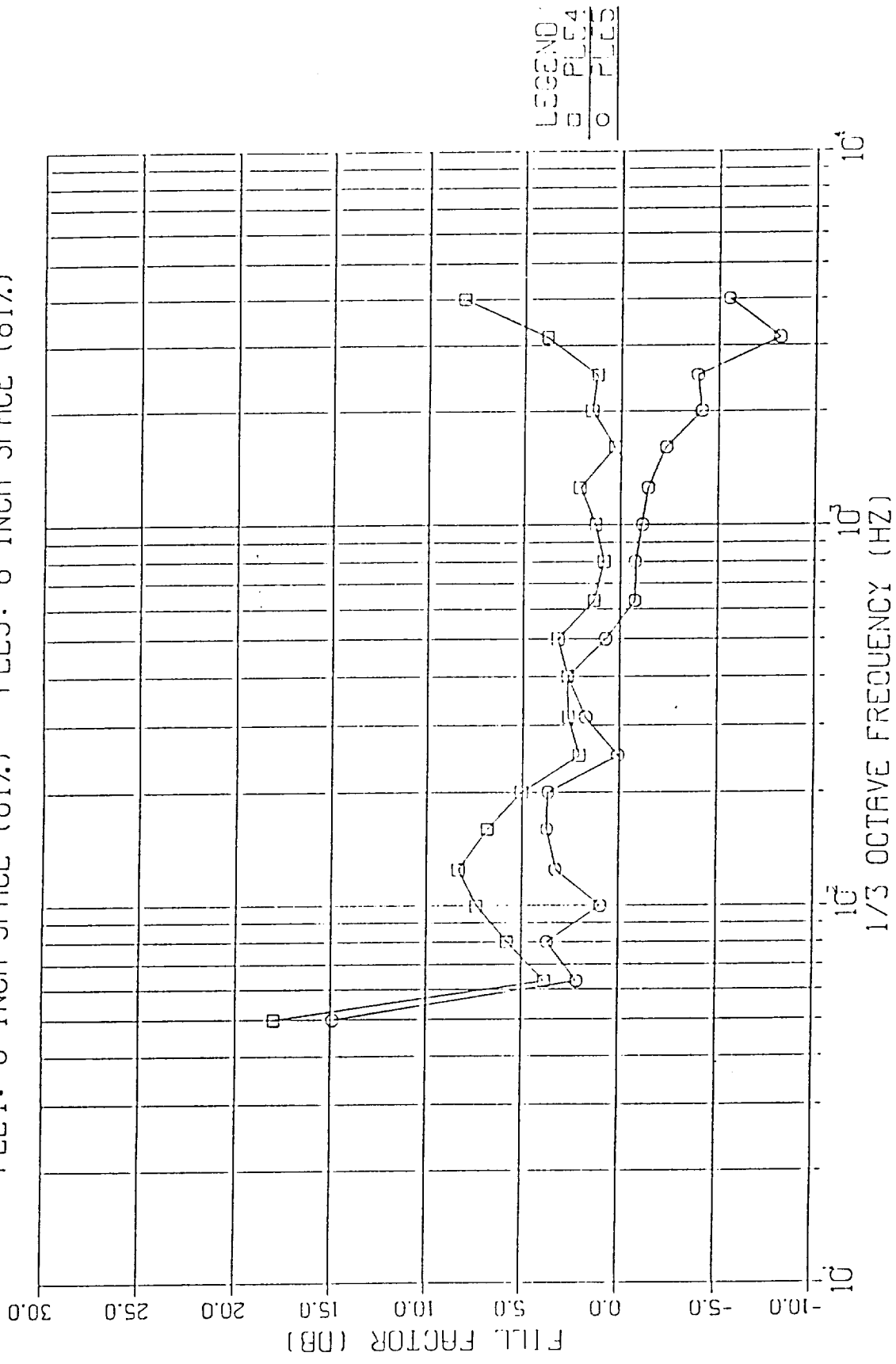


Figure 14 Weighted Fill Factor of Configuration E in 120-inch Diameter Fairing

8-IN: CONF A (75%)-CFAC PLE4,PLE5: CONF E (81%)  
 VAP70: VAPEPS (70%) VAP80: VAPEPS (80%)

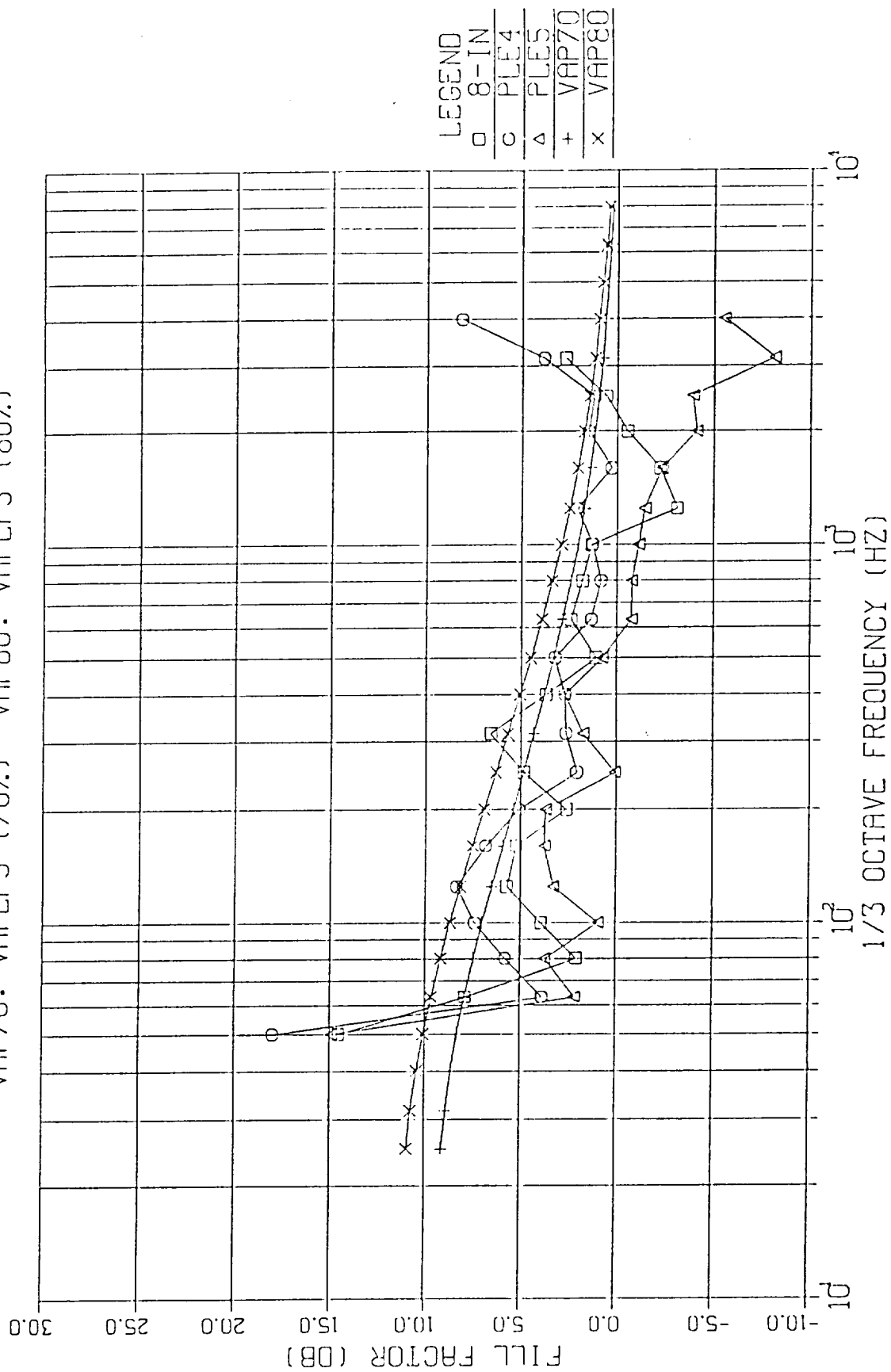


Figure 15 Comparison of Fill Factors for 120-inch Diameter Fairing

VAPEPS: 50% FEM1/FEM2: CONST/SCHEDULED DAMPING  
 CONF B: 26 INCH (54%) CONF C: 30 INCH (49%)

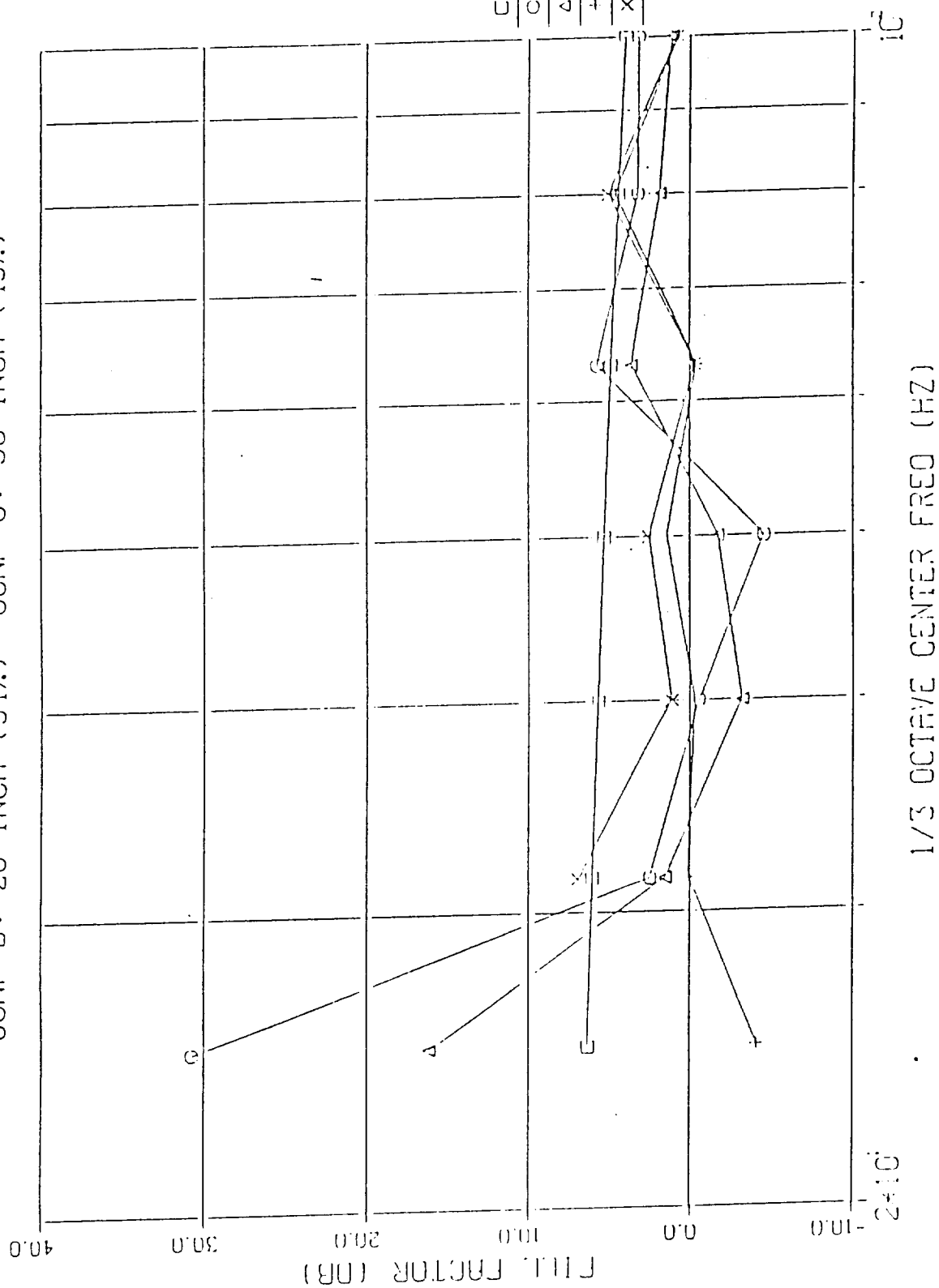


Figure 16 Comparison of Fill Factors for 200-inch Diameter Fairing (Figure 4.15 in ref. 1)